ON INTERGROWTHS OF HORNBLENDE WITH AUGITE IN CRYSTALLINE ROCKS.

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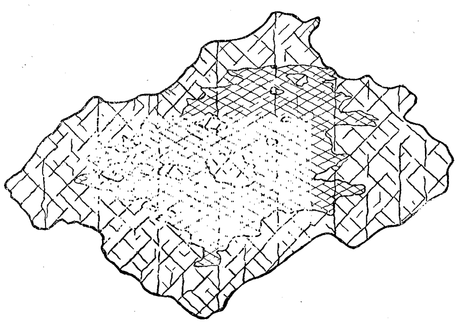
THE question of the primary or secondary origin of hornblende in a number of types of eruptive and metamorphic rocks is one of the most difficult to answer of any that are raised by their study. The number of varieties under which the calcium magnesium iron silicates that we call hornblende occurs, makes it a somewhat difficult matter to correlate results. The term "Uralite," which Gustave Rose applied to a fibrous hornblende from the Urals, which was pseudomorphic to hornblende, has sometimes been loosely applied to any variety of hornblende which may be supposed to have this origin. Other observers have distinguished "compact hornblende" from uralite, and have also carefully stated the character of the mineral's absorption. Uralite, when applied with the proper restrictions, is always an alteration product of pyroxene. It is a matter of the commonest occurrence to find basic eruptive rocks, particularly diabase, in which the alteration of augite to this mineral can be clearly seen. As regards the compact variety, it has been described as secondary to augite by Hawes,[1] Irving and Van Hise,[2] and Williams.[3]

In the beautiful monograph on the "Eruptive Rocks of Electric Peak and Sepulchre Mountain, Yellowstone National Park,"[4] Professor J. B. Iddings devotes considerable space to the description of very interesting intergrowths of augite and hornblende, both in diorites and glassy rocks. The author uses the opportunity to raise a strong doubt as to the secondary nature of compact hornblende in those cases in which it has been described. Because of



the deservedly wide reputation of Professor Iddings, his generalizations regarding this point will be received with much consideration. It has seemed to the present writer that Mr. Iddings should have made mention of earlier descriptions of intergrowths of these minerals where the primary nature of the hornblende has been as clearly demonstrated as in the cases he describes.

Parallel intergrowths of augite and hornblende have been frequently observed in eruptive rocks. Teall,[5] Rohrbach,[6] myself,[7] and probably others have figured them. Rohrbach described intergrowths in a teschenite, from the Teufelsgrund, in which the hornblende has its own outlines and is sharply outlined from augite. Chemical analysis showed an essential difference in composition between the augite and hornblende. I have described very similar growths in the augite diorite from Medford in Massachusetts. Here the hornblende is the brown variety and the augite the pink variety common in diabases. That the hornblende is primary is shown not only by its idiomorphic character, but also by the fact that the augite is sometimes almost entirely altered to clorite, the hornblende remaining fresh. Professor Iddings's conclusions will doubtless go far toward correcting any tendency to describe compact hornblende as secondary when the principal basis for it is the analogy with uralite, as his observation of an instance of hornblende altered to augite brings into the study of the relations of these minerals a new complication.

I have recently observed some rather unusual intergrowths of augite and hornblende in a rock from the "Cleveland Gold Mine" in New Marlboro, Mass. The rock is largely composed of these minerals, but is slightly calcareous and is apparently a phase of crystalline limestone. Nearly all the crystals represent intergrowths, the hornblende generally predominating and enclosing the augite, which is of irregular outline and oriented like the hornblende. Prismatic sections show a wide divergence in the extinction angles, and the hornblende is light-green and pleochroic, while the augite is almost colorless. The intergrowth figured is interesting because the augite in this instance completely surrounds the hornblende, a structure that I think is rare, as I have not seen it described. The section is nearly perpendicular to the *c* axis, since the cleavage angle in the augite was measured as 89°–90°, and that of the hornblende as 125°. While sharply contrasted by differences in their color and cleavage angle, the two minerals are more markedly distinct in polarized light. I have noticed other instances of intergrowths of these minerals within the same area, but this is the only one where hornblende was seen to be entirely enclosed by augite.

An examination of the section figured will show how intricate is the intergrowth. Islands of augite are enclosed within the hornblende. A somewhat pronounced parting parallel to the clino-pinacoid passes through both minerals. There seems to be considerable similarity between intergrowths of these minerals and the quartz which is so often enclosed within the feldspar of pegmatites. The hornblende, like the feldspar, is most frequently the enclosing mineral, and in the instance described by Rohrbach it is, like the feldspar, the more basic of the two minerals.

[1] Mineralogy and Lithology of New Hampshire, Plate vii., Fig. 1.

[2] Geology of Wisconsin, iii, 170; iv., 662. American Journal of Science (3), xxvi., 29.

[3] Ibidem, xxviii., 259–268.

[4] Extract from the Twelfth Annual Report of the Director of the U. S. Geological Survey.

[5] Quarterly Journal of the Geological Society, London, xl., 653, Plate xxix., Fig. 3

[6] Ueber die Eruptivgesteine in Gebiete der schlesischen-mährischen Kreideformation. Min. u. petrog. Mitth., vii., 24, Plate i., Figs. 1–7.

[7] On the Petrographical Characters of a Dike of Diabase in the Boston Basin. Bull. Comp. Zoöl., Harv. Coll., xvi., 10, Plate i., Fig. 2.

OPTICAL ANGLE AND ANGULAR APERTURE.

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THE observation of the brilliantly-colored images which are given by various crystals, natural and artificial, in polarized light is of considerable diagnostic value. The apparent breadth between the two branches of the hyperbola which may be seen in the image given by many biaxial substances, e.g., white mica, is dependent upon the optical angle,—a constant characteristic of them. The relation between this breadth and the "optical angle in air" (2E) is usually found by noting the apparent breadth in the case of a plate whose optical angle is somehow otherwise known (see Iddings's translation of Rosenbusch's "Microscopic Physiography," also Czapski in the Neues Jahrbuch für Mineralogie, etc., 1892, supplementary vol. vii.).

I wish to describe briefly the very simple method that I use for determining said relation, which also may be used *to determine the angular aperture of the objective.*

It works well in class, and the only reason why it has not long ago been adopted seems to be that the German microscopes on which the technique of the subject has been developed are not built to admit of it. But any microscope whose mirror-bar is graduated to measure the obliquity of the light will do.

We will suppose, then, that we have such a microscope, that above and below our plate of mica we have nicols, below it a strong condensor, and above a short-focus objective.

We may use a camera and project the image with its hyperbola on paper, but we will suppose that instead of that we use a Bertrand lens, which slips into the tube between eye-piece and objective, and with the former makes a compound microscope which magnifies the image given by the objective alone. We will also use a micrometer eye-piece. To measure the distance between the hyperbola branches, the micrometer scale must run diagonally. After noting the position of the branches on the scale, turn it till it runs right and left, the same way that the mirror swings. Then, without altering the distances between Bertrand lens, objective, and eye-piece, lower the whole tube until the front of the